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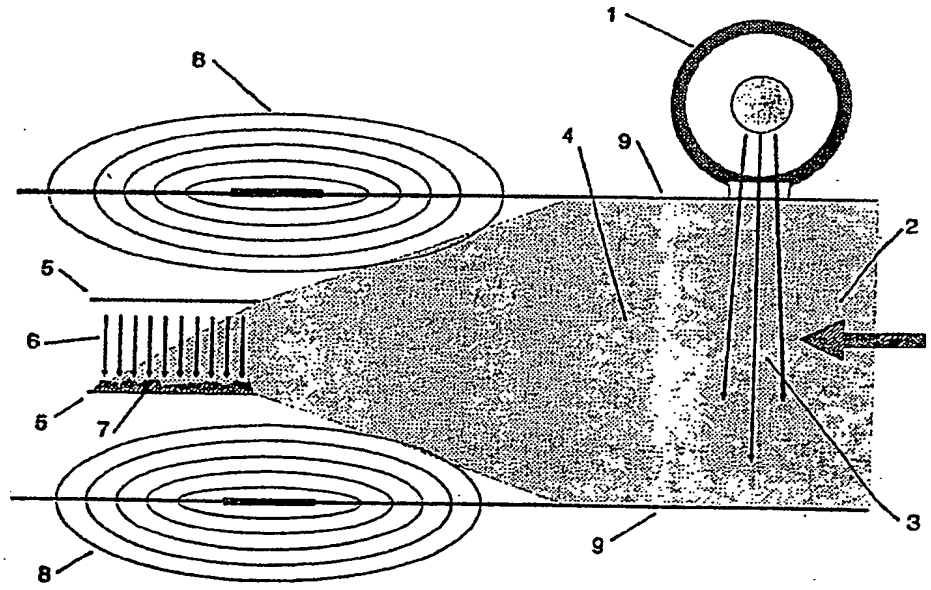
(54) Title: METHOD TO PURIFY GASES




(57) Abstract

The object of the invention is a method to purify gases, such as combustion gases, in which method oxides of nitrogen and sulphur are converted into solid particles by an electron beam coming from an electron source (1) with the aid of added base. By the present methods oxides of nitrogen and sulphur cannot be removed effectively. In the method of the invention particles charged in the electron beam are guided with an external electric field to gather on a collection sheet (5) into a layer (7) which can be cleaned at desired time periods.

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# METHOD TO PURIFY GASES

The object of the invention is a method to purify gases, such as combustion gases, in which method oxides of nitrogen and sulphur are converted into solid particles by an electron beam coming from an electron source, with the aid of added alkaline.

The mostly used method to purify combustion gases these days is a method, in which an electric filter is used to remove the solid particles, and slaked lime, which binds to itself part of the sulphur oxide formed during the burning process, is fed into the furnace of the boiler. This slaked lime dust is then filtered off in the electric filter with all the other solid particles. Usually nitrogen oxides are not even attempted to be removed, but the burning process is designed such that the temperature is low all the time, which reduces the amount of nitrogen oxides produced. In principle the lowered temperature does not reduce the amount of heath produced, but, because power plants generally produce electricity, according to the theoretical Carnot's machine the efficiency of electricity production is reduced as the temperature difference used by the machine is reduced. The efficiency of the Carnot's machine is $(T_2 - T_1)/T_2$ $(T_2 > T_1)$, that is, the temperature of the boiler can not be lowered very much without a significant reduction in efficiency. Power plants have also been designed, in which the combustion gases would be in such a high temperature that they would already be so strongly ionized, that electricity could be formed directly from these charge carriers by separating them into collection surfaces of opposite charge with the aid of a magnetic field. Then, if there is nitrogen present, it certainly burns into oxide. By adding washing methods of combustion gases, of which wet washing is most general, to the above described primary purification methods, 80 % of sulphur can usually be removed. Even with these washing methods nitrogen oxides can not be removed

without expensive special chemicals. A great disadvantage of the wet washing methods is also a huge amount of dirty water which is usually cleaned and recycled.

Today electric filters are good in removing solid material sufficiently. Perhaps their greatest disadvantages are the duration age of the wires used in the corona discharge, and keeping the corona discharge voltage at the breakdown level.

The aim of the invention is to achieve a method to purify gases, which in addition to removing solid material also efficiently removes $SO_2$ and most of NO.

The aim of the invention is achieved by a method which is characterized in the claims.

In the method of this invention, particles in the gas, that have been charged by an electron beam, are guided to gather on a collection surface with the aid of an external electromagnetic field, and this collection surface is cleaned at desired time intervals. In this method dust-like lime or some similar material, which removes part of the sulphur oxides directly and, together with the moisture in the combustion gases or added water, neutralizes nitrogen acid and sulphuric acid formed in the electron beam of NO and $SO_2$ ( NO + electron-beam -> $NO_2$ + $H_2O$ -> $HNO_3$; $SO_2$ + electron-beam -> $SO_3$ + $H_2O$ -> $H_2SO_4$ ), is added into the furnace of the boiler. In addition to lime, also ammonium added into the combustion gases can act as a neutralizer. In other words, the electron beam converts the weakly reacting NO and $SO_2$ to effectively reacting nitrogen acid and sulphuric acid, which are neutralized with bases into salts that form solid particles. This is known technology, which has not yet been used, mainly because inexpensive, effective electron beam devices with a good efficiency have not been available. According to earlier methods, burned nitrogen and sulphur, after they have been converted into solid material,

have been removed with electric filters. In this invention the charge of the particles is exploited, because immediately after the electron beam all solid particles have been charged with a strong negative charge by the electron beam. With the charge and an external electromagnetic field the particles can be guided to wanted positions. The currents of the electron beams are very high, for example in a 100 MW power plant with electron energy of 330 keV, the electron beam current is 300 A. In a coal power plant of equal size, the current needed by the electric filter is (the amount of combustion gases per second : 200 $m^3$) 100 $m^2/m^3$ 0,1 mA = 2 A. That is, when calculated without the ionization effect the current in the electron beam is more than hundredfold. In other words, it can be shown that ionization is apparently much more effective in the electron beam than in the gas discharge, taking into account also the fact that the voltage in the electron beam is about five times higher than in the gas discharge. So the power put to the ionization in the electron beam device is about 1000 times greater when compared to the power in the electric filter based on gas discharge. This means that distances between the collection sheets can be longer and collection areas can be smaller.

In the following the invention is explained in more detail with reference to the appended drawings, where figure 1 presents one embodiment the method, and figure 2 presents another embodiment of the method.

In figure 1 the electron beam source 1 has been installed beside the combustion channel 9 in such a way that the electron beam 3 is injected by it into the gas flow 2 in the combustion channel 9. After going through the electron beam the gas is ionized and the previously mentioned reactions take place so that most of the nitrogen and sulphur oxides are converted into solid particles in the area 4, which particles are charged negatively by the electron beam. When

the gases have gone a little further, the negative particles are guided between the collection sheets 5 by the electromagnetic field 8. In this embodiment the electromagnetic field is produced economically by an organ shaped like a ring. Between the collection sheets 5 there is a separate electric field 6 from one sheet to the other perpendicular to the gas flow. The electromagnetic field which acts as a collection field 6 forces the solid material into the surface of the other collection sheet 7, from where it is removed for example with a mechanical impact or with a fast electrical counter impulse.

In figure 2, the charged particles are collected into successive collection sheets 5 with collection guidance electric fields 10, 11. The collection sheets are in a positive potential referred to the body. There is also a separate collection field 6 in the collection sheets. There can be two or more successive sets of collection sheets and the collection guidance electric field 11 can be controlled with separate controllers 12, which are in different potentials, and for example shaped like a ring. The collection sheets can also be in several layers, in which case each of them is charged to a higher potential than the previous one, or every other sheet is charged to a higher potential. The figures are schematic diagrams which can in reality of course be more complicated and for example in different positions for the removal of solid material.

The invention is not restricted to the presented embodiments, but it can be altered according to the claims and applied also to purify other than combustion gases.

CLAIMS

1. Method to purify gases, such as combustion gases, in which method oxides of nitrogen and sulphur are converted into solid particles by an electron beam (3) coming from an electron source (1) with the aid of added base, *characterized* in that particles charged in the electron beam are guided with an external electric field to gather on a collection sheet (5) into a layer (7) which can be cleaned at desired time periods.

2. Method in accordance with claim 1, *characterized* in that the particles charged by the electron beam (3) are guided with a spesific collection guidance field (10, 11) between the collection sheets (5) which there can be two or more successive sets.

3. Method in accordance with claim 2, *characterized* in that, for shaping the collection field, organs (12) which are in different potential than the collection sheets are used between the collection sheets and the wall of the combustion channel.

4. Method in accordance to some of claims 1-3, *characterized* in that there are several collection sheets (5) in layers so that every other layer has a higher potential.

5. Method in accordance to some of claims 1-3, *characterized* in that the solid material collected on the collection sheets (5) is removed with a fast electric impulse which has opposite polarity than the voltage of the collection field.

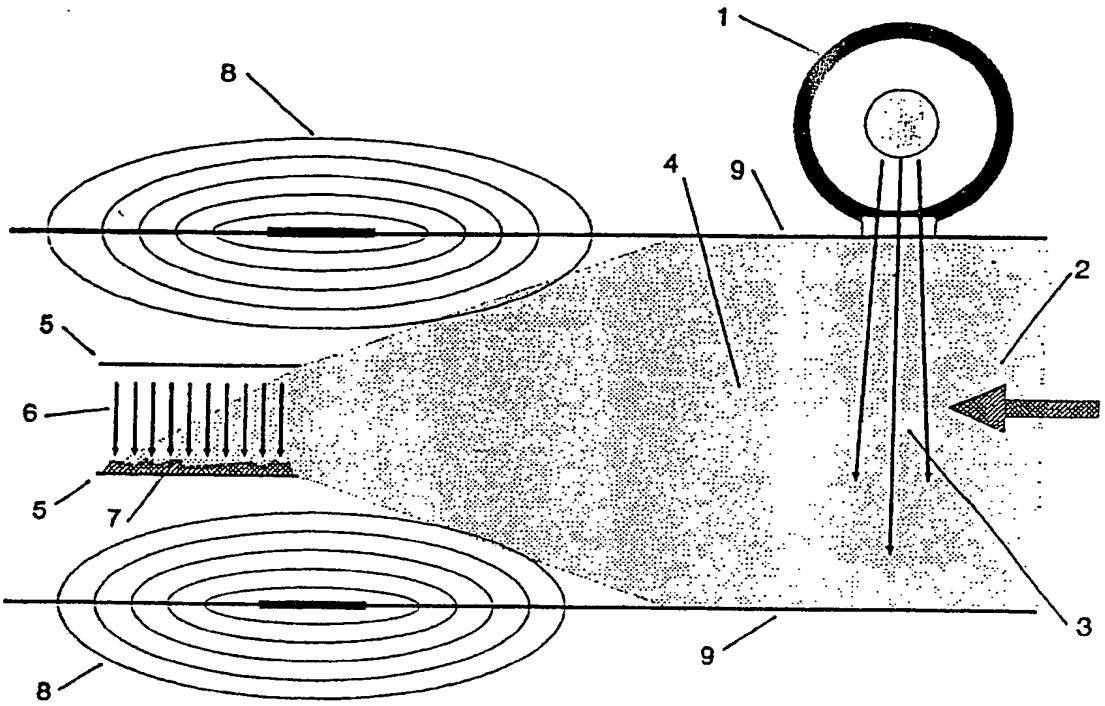


FIG.1

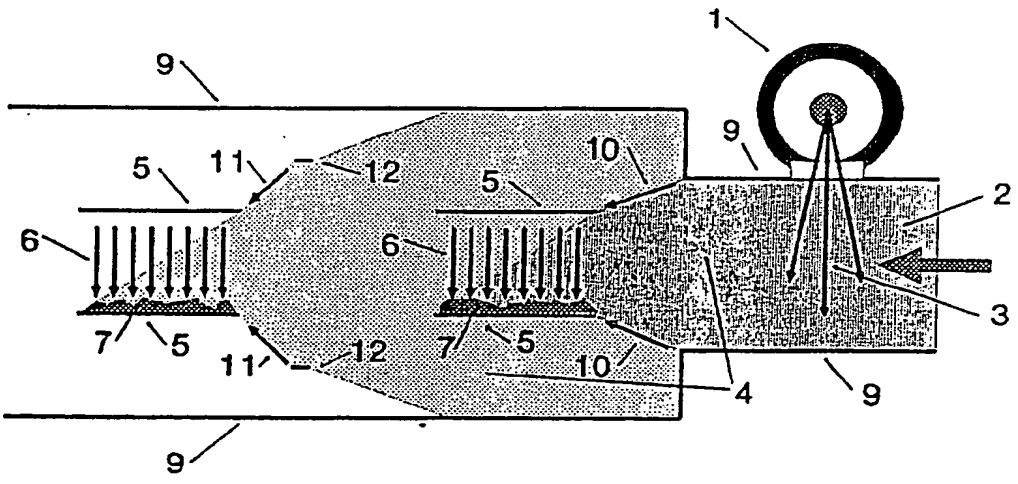


FIG.2

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 92/00343

## A. CLASSIFICATION OF SUBJECT MATTER

IPC5: B01D 53/34, B01D 53/32 // B03C 3/12
According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

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IPC5: B01D, B03C

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## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | EP, A1, 0326686 (EBARA CORPORATION), 9 August 1989 (09.08.89), page 4, line 4 - line 57, figure 3 -- | 1 |
| A | EP, A2, 0424335 (OY AIRTUNNEL LTD), 24 April 1991 (24.04.91), page 2, figures 1-3 -- | 1 |

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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| Date of the actual completion of the international search | Date of mailing of the international search report |
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
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| A | Patent Abstracts of Japan, Vol 9,No 260, C-309, abstract of JP, A, 60-114362 (NIPPON JIDOSHA BUHIN SOGO KENKYUSHO K.K.), 20 June 1985 (20.06.85) | 1 |

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Information on patent family members

29/01/93

International application No.
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| EP-A2- 0424335 | 24/04/91 | AU-A- 6109090 | 28/02/91 |
| | | CA-A- 2023911 | 26/02/91 |
| | | JP-A- 3098614 | 24/04/91 |